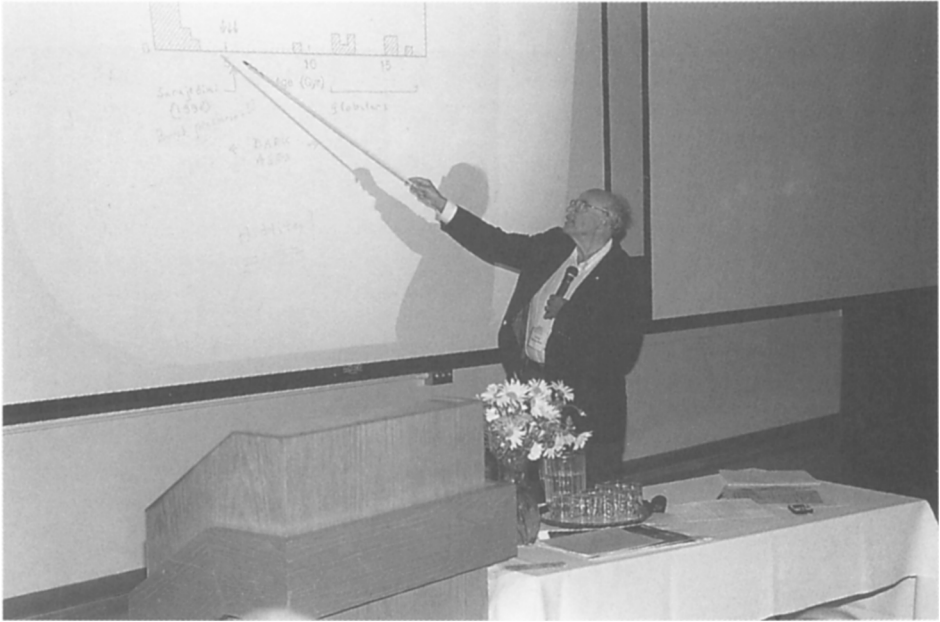


Part 9. Summary



Sidney van den Bergh presents the Symposium summary. That's Gretchen Harris in the "front row, right-hand side, on the aisle" seat that Sidney habitually occupied during colloquia while Gretchen was a University of Toronto graduate student (see page 2).

The Magellanic Clouds, Past, Present and Future - A Summary of IAU Symposium No. 190

Sidney van den Bergh

*Dominion Astrophysical Observatory
Herzberg Institute of Astrophysics
National Research Council of Canada
5071 West Saanich Road
Victoria, British Columbia
Canada V8X 4M6*

1. Introduction

Important problems to which we would like to find answers are:

- What are the distances to the Large Magellanic Cloud (LMC) and the Small Magellanic Cloud (SMC)?
- What is the present distribution of stars, gas and dark matter in the Clouds, and how did it evolve?
- How, and where, did the Magellanic Clouds form, and how have their orbits evolved?
- Finally the recent discovery of numerous microlensing events in the Clouds provides answers to questions that we have only recently started to ask.

For background material on the Clouds of Magellan the reader is referred to IAU Symposium No. 108 (van den Bergh & de Boer 1984), IAU Symposium No. 148 (Haynes & Milne 1991), and to the recent monograph *The Magellanic Clouds* (Westerlund 1997). The sections of this summary of the conference proceedings are given approximately in the order in which they were presented at the symposium.

2. Interstellar Matter

2.1. Optical Imaging

A number of authors presented beautiful narrow-band images of both the LMC and the SMC, which showed an intricate network of hot bubbles produced by the stellar winds of giant associations, and shells formed by exploding supernovae. From the close association between supernova remnants (SNRs) and emission nebulae Petre (NASA/GSFC) concluded that the majority (35 out of 48) of the SNRs observed in the Large Cloud had been produced by supernovae of Type II (SNe II). However, the fact that the SNR N 103B [which was produced by a SN Ia (Hughes et al. 1995)] is associated with an H II region shows that individual type assignments based on environment may be incorrect. In the SMC

the presently available data are insufficient to derive the relative numbers of SNe Ia and SNe II. It would be of interest to compare recent narrow-band images of the Magellanic Clouds with digitized versions of similar images obtained a few decades ago, to search for the light echoes of prehistoric supernovae in the Clouds. Sonneborn (NASA/GFSFC) et al. reported on the recent development of a hot spot associated with the forward shock produced by SN 1987A, that is now beginning to enter the dense gas on the inner-most edge of the ring surrounding this supernova. This may be the beginning of the “second coming” of SN 1987A!

2.2. Millimeter Radio Observations

Beautiful new ^{12}CO ($J = 1 - 0$) observations obtained with the NANTEN telescope on Las Campanas were shown by various Japanese groups. Due to low metallicity molecular clouds are found to be rarer in the LMC than they are in the Galaxy. Not unexpectedly such clouds are seen to be even scarcer in the SMC. Over the mass range $10^5 M_{\odot}$ to $10^6 M_{\odot}$ Mizuno (Nagoya) et al. find that these molecular clouds have a power law mass spectrum of the form $dN/dM \propto M^{-1.5}$. Saito (Nagoya) et al. note that the positions of H II regions are strongly correlated with those of giant molecular clouds (GMCs). The positions of young star clusters are slightly less correlated with those of GMCs. Finally there is little evidence for a correlation between the positions of SNRs and GMCs. This suggests that most GMCs have lifetimes that are short compared to the $\geq 1 \times 10^7$ yr time-scale for the evolution of SNe II.

2.3. 21-cm Observations

A number of interesting new results, based on observations obtained with the Australia Telescope Compact Array (ATCA), were presented at the meeting. The neutral hydrogen observations by Dickey (U. Minnesota) et al. show that the cool atomic phase is quite abundant in the Clouds. Possibly such cool gas would have been transformed into molecular clouds in the dust-rich Galactic environment. Alternatively the Galactic gas may have been warmed by photoelectric heating of small grains. The hydrogen gas in the LMC forms a well-defined rotating disk, whereas that in the SMC appears chaotic. The LMC rotation curve implies a total disk mass of $2.5 \times 10^9 M_{\odot}$ within 4 kpc of the kinematic center of the Large Cloud. The total amount of neutral gas (including He) in this disk is $5 \times 10^8 M_{\odot}$. Observations with the ATCA show a number of features in the outer regions of the LMC that have been stretched into transient spiral arm-like structures by differential rotation. From their $\sim 20^\circ$ pitch angle Staveley-Smith (ATNF) estimates an age of ~ 90 Myr for these features. The ATCA survey shows an intricate system of bubble-like structures in both the LMC and SMC. A few of these bubbles appear to have no central cluster/association or supernova remnant. The origin of such bubbles is a mystery.

2.4. Absorption-line Spectroscopy

Hot ($T > 10^5$ K) gas is best observed in the ultraviolet absorption lines of highly-ionized atoms, such as O^{+5} , N^{+4} , C^{+3} and Si^{+3} . Such lines may form near O3-O7 stars in the LMC disk, or in a hot gaseous corona around the Large Cloud. Wakker (U. Wisconsin) has been able to use the *Hubble Space Telescope* (HST)

to show that some lines of sight, which do not pass close to any early O-type stars, show strong C IV absorption. A comparison of the velocities of such hot gas with that of H α emission shows that it is not co-spatial with disk material. This suggests that this hot gas is located in a corona around the LMC. The LMC is found to contain an extensive distribution of hot plasma which radiates $\sim 10^{38}$ ergs s $^{-1}$ in the 0.5-2.0 keV band. The SMC emits only $\sim 10^{37}$ ergs s $^{-1}$ in this energy band. De Boer et al. (1998) have detected H $_2$ in absorption along various lines of sight towards the LMC. They derive excitation temperatures ≤ 50 K for levels $J \leq 1$ and ~ 470 K for levels $2 \leq J \leq 4$. From these observations they conclude that moderate UV pumping affects even the lowest levels of excitation towards the LMC. Richter et al. (1998) have detected an H $_2$ cloud with an excitation temperature $\simeq 70$ K at +120 km s $^{-1}$ towards the SMC, while another feature at +160 km s $^{-1}$ has an excitation temperature > 2300 K, which must be due to strong UV radiation from its energetic environment.

3. The History of Star Formation in the Clouds

3.1. Massive Stars

The determination of the slope of the mass spectrum of star formation in the Clouds of Magellan has a long and sordid history. Massey (KPNO) pointed out that many of the problems encountered by previous investigators had been due to the fact that they only used photometric data to determine the slope of the mass function Γ . Massey finds that much more consistent results can be obtained by combining spectroscopic and photometric data on massive stars. He finds that $\Gamma = -1.4 \pm 0.2$ in the LMC, $\Gamma = -1.3 \pm 0.1$ in the SMC, and $\Gamma = -1.3 \pm 0.4$ in the Milky Way. These results suggest that the mass spectrum of star formation may be universal. Massey called attention to the fact that $\Gamma = -1.4 \pm 0.1$ in the super-compact cluster R 136, which is situated at the center of 30 Doradus complex. This value is identical to that for other regions of star formation in which the stellar density is two orders of magnitude lower. Walborn (STScI) pointed out that populations of differing age can be recognized in the 30 Dor region: (1) The central ionizing cluster R 136, which has an age of 2-3 Myr, (2) a younger generation of early-O stars and IR sources that are embedded in bright nebular filaments to the west and northeast of R 136, (3) an older population of late-O and early-B supergiants, having an age of 4-6 Myr that is scattered throughout the 30 Dor region, (4) a still older compact cluster 3' northwest of R 136 that contains A and M supergiants having ages of ~ 10 Myr, and (5) a 4-6 Myr old association, that includes the luminous blue variable R 143 in the southern part of the nebula. In other words it appears that star formation in the 30 Dor region is an ongoing process, rather than a single event.

Langer & Heger (U. Potsdam) have compared theoretical predictions of the frequency distribution of massive evolved stars (Hess diagram) with observations and conclude that (1) theory yields a gap to the right of the main sequence that is not observed, and (2) theory predicts a dependence of [Fe/H] on the ratio of luminous blue stars to M-type supergiants that is in the opposite sense to that which is actually observed. They suggested that these problems might be resolved by using both [Fe/H] *and* rotation in stellar models. Such rotational mixing will destroy the onion-like internal structure of non-rotating stellar mod-

els. In the discussion following their presentation Massey suggested that both (1) and (2) might be partly accounted for by observational selection effects.

Element ratios are potentially important sources of information on evolutionary history. Smith (U. Texas) showed that the abundance ratio of the r-process element europium to that of the s-process element barium is higher in the Magellanic Clouds, than it is for stars of similar metallicities in the Galaxy. Since the mass spectrum of star formation appears to be universal this effect cannot be due to differences in the frequency with which SNe II having different progenitor masses occur.

A problem of long standing (Richtler, Spite & Spite 1991, and references therein) is that stars in the young SMC cluster NGC 330 appeared to be more metal deficient than similar stars in the SMC field. Such a difference would be difficult to explain. However, new work by Hill (Paris Obs.) appears to show that the abundance differences between NGC 330 and the SMC field, and between NGC 1818 and NGC 2100, and the LMC field are not significant.

De Boer et al. (1997) have recently proposed that star formation may be triggered as gas is compressed in a bow-shock formed at the leading edge of the LMC. Such a scenario would favor star formation at the SE edge of the Large Cloud, where the cumulative effects of the space motion and rotation of the Large Cloud are greatest. However, a recent study of the distribution of 2138 supergiants and 1170 Cepheids by Grebel (Lick Obs.) & Brandner (JPL) does not appear to support the bow-shock scenario. This suggests that the Galactic halo gas density is negligible at $R_{GC} \sim 50$ kpc.

3.2. History of Star Formation in the Large Cloud

Observations of field stars in the LMC by Butcher (1977) showed that a burst of star formation, that has continued to the present day, started in the Large Cloud 3-5 Gyr ago. This conclusion has been supported by all subsequent studies. However, the magnitude of this increase in the rate of star formation, that occurred ~ 4 Gyr ago, remains controversial. Using HST observations in three outer fields Geha et al. (1998) find that the rate of star formation increased by only about a factor of three. Gallagher (U. Wisconsin) detected no evidence for significant differences between the evolutionary histories in different LMC fields. However, Romaniello (STScI/Pisa) et al. find that the rate of star formation in the field surrounding SN 1987A is presently an order of magnitude higher than it was ~ 5 Gyr ago. On balance, it appears that available data from Large Cloud field stars (Geha et al. 1998) indicate that half of all LMC stars formed during the last 4 Gyr, with the other half having formed during the preceding ~ 10 Gyr. Da Costa (MSSSO) showed that this contrasts dramatically with the situation for star clusters in the Large Cloud. Elaborating on earlier work (Da Costa 1991) showed that the rate of cluster formation in the LMC was close to zero between ~ 4 Gyr ago, and the era of globular cluster formation ~ 14 Gyr ago. Taken at face value his data suggest that the rate of cluster formation had increased by almost two orders of magnitude ~ 4 Gyr ago. This conclusion was strengthened by Sarajedini (1998) who found only 3 new clusters with ages ~ 5 Gyr in the ~ 10 Gyr age gap between the era of globular cluster formation and the burst that started ~ 4 Gyr ago. The existence of these clusters might indicate that the burst "ramped-up" for ~ 1 Gyr before reaching maximum intensity ~ 4 Gyr

ago. *The dramatic contrast between the history of cluster formation and that of field stars suggests that star clusters cannot be used as proxies for star formation.* In fact, it would have been very difficult to understand how stars with elevated [Fe/H] values could have formed ~ 4 Gyr ago if star (and supernova!) formation rates had remained depressed during the preceding “dark ages”. The observation that the Local Group galaxy IC 1613 is forming young stars but few (if any) star clusters (Baade 1963; van den Bergh 1979), provides a clear demonstration of the fact that the rate of star formation in galaxies does not need to be closely correlated with the rate of cluster formation. In fact, Hodge (1998) finds that the rate of cluster formation, normalized to similar rates of star formation, is presently ≥ 600 times greater in the LMC than it is in IC 1613. The observation (Whitmore & Schweizer 1995) that star clusters are being formed very actively in the violently interacting galaxies NGC 4038/39 (“the antennae”) suggests that strong shocks might favor the formation of clusters. Finally, it is of interest to note that the rate of star and cluster formation in the SMC (Mighell, Sarajedini & French 1998) appears to have proceeded at a more-or-less constant rate over the last ~ 10 Gyr. This shows that tidal interactions between the Clouds cannot be invoked to account for the LMC starbursts that started ~ 4 Gyr ago.

3.3. Early Star Formation

Olsen (U. Washington) et al. used deep HST observations to show that the LMC globular clusters NGC 1835, NGC 1898, NGC 1916, NGC 2005, and NGC 2019 have ages that differ by ≤ 1 Gyr. Similar results were obtained for NGC 1466, NGC 2259 and Hodge 11 by Johnson (UCSC) et al. Furthermore the absolute ages of these clusters are found to be similar to those of the Galactic globulars M 3, M 5 and M 55. These results suggest that the Population II component of the Large Cloud formed during a short, but intense, burst of star and cluster formation. On the other hand deep HST observations of clusters in the SMC by Mighell (NOAO) et al. show a rather more gradual onset of cluster formation, with the oldest SMC cluster NGC 121 having an age of only 10.6 ± 0.7 Gyr. Hesser (DAO) et al. also used HST observations to show that the luminous outer halo Galactic globular NGC 2419, which is located at $R_{Gc} \sim 100$ kpc, has an age similar to that of the globular clusters in the LMC and in the main body of the Galactic halo. On the other hand they find that the fainter outer Galactic halo clusters Palomar 3, Palomar 4 and Eridanus have lower ages that are similar to that of NGC 121 in the SMC. The picture that emerges from these results is one in which massive globular clusters formed almost simultaneously in the LMC, and the inner and outer halo of the Galaxy, i.e. throughout a region with a radius of ~ 100 kpc. Less luminous massive clusters formed in the outer Galactic halo and in the SMC during the next few Gyr.

Grebel (Lick Obs) et al. strengthened observational data which show that both Magellanic Clouds shrank as they evolved, with the oldest Population II component occupying a larger volume than younger stars belonging to Population I. Van den Bergh (2000) has noted a similar effect in all other Local Group dwarf irregulars in which detailed population studies have so far been made.

4. The Distances to the Magellanic Clouds

4.1. Distance to the Large Cloud

Distance determinations to the LMC prior to 1996 have been reviewed by Westerland (1997). An unweighted mean of these data yields a mean distance modulus $\langle (m - M)_o \rangle = 18.48 \pm 0.04$. A tabulation of 16 more recent distance determinations, which was handed out at the Symposium by van den Bergh, yields an unweighted mean value $\langle (m - M)_o \rangle = 18.50 \pm 0.04$. Three of the determinations listed in this table give results that are inconsistent with this mean: Using *Hipparcos* parallaxes Feast & Catchpole (1997) find $(m - M)_o = 18.70 \pm 0.10$. However, after applying Lutz-Kelker corrections Oudmaijer et al. (1998) obtain a smaller value $(m - M)_o = 18.56 \pm 0.08$. The appropriateness of these corrections was, however, disputed by Feast. A second discordant distance to the LMC was found by Udalski et al. (1998), who obtained $(m - M)_o = 18.08 \pm 0.03 \pm 0.12$ (systematic) from the mean magnitude of red clump giants in the LMC. A rediscussion of these results (Cole 1998) yields a larger modulus $(m - M)_o = 18.36 \pm 0.17$. Even more recently Paczyński (1998) has questioned the validity of using the magnitudes of clump stars as distance indicators. Finally Reid (1997) has obtained a discordant modulus of $(m - M)_o = 18.71 \pm 0.06$ by fitting the RR Lyrae variables in the LMC globulars NGC 1466 and NGC 2257 to those in the Galactic globular cluster NGC 6397. From this fit Reid obtains $(m - M)_o = 18.71 \pm 0.06$. The weak link in this chain might be the fit of the main sequence of NGC 6397 to the *Hipparcos* parallaxes of nearby subdwarfs.

Perhaps the most direct determinations of the LMC distance are those which are purely geometrical in nature. At the meeting Pritchard (Mt. John Obs.) et al. presented observations of the detached early-type eclipsing binary HV 2274 from which they obtained $(m - M)_o = 18.44 \pm 0.07$. Five additional detached early-type binaries in the LMC have yet to be observed and might strengthen this distance determination. A second purely geometrical method of distance determination is based on ultraviolet observations of the SN 1987A ring. Panagea (STScI/ESA) showed that these data yield $(m - M)_o = 18.55 \pm 0.05$ for the supernova, and $(m - M)_o = 18.58 \pm 0.05$ for the centroid of the LMC. In view of these results it seems safest to continue to use the canonical value $(m - M)_o = 18.5 \pm 0.1$, corresponding to $D(\text{LMC}) = 50$ kpc.

4.2. Distance to the Small Cloud

The SMC distance determinations prior to 1996 have been reviewed by Westerland (1997). An unweighted mean of these data yields $\langle (m - M)_o \rangle = 19.94 \pm 0.05$. After excluding the red clump modulus of Udalski et al. (1998), for the reasons discussed above, one finds a mean unweighted value of $\langle (m - M)_o \rangle = 18.85 \pm 0.04$ for the SMC from distance determinations that have been published recently. It is, however, a source of grave concern that the four Cepheid-based determinations yield $(m - M)_o = 18.93 \pm 0.03$, which is inconsistent with $(m - M)_o = 19.73 \pm 0.02$ that is derived from five distance determinations based on RR Lyrae variables. Kunkel (private communication) has suggested that this difference may be due to the great depth along the line of sight of the SMC. Perhaps many of the young Cepheids in the Small Cloud are located in the tidal tail behind main body of the SMC. In summary it appears that the distance

modulus of the Small Cloud is probably $(m - M)_o = 18.85 \pm 0.1$ (corresponding to $D = 59$ kpc), with the caveat that young stars might, on average, be more distant than the main body of this galaxy. Caldwell & Coulson have pointed out that the distance modulus of the Wing of the SMC is probably ~ 0.3 mag smaller than that of the main body of the Small Cloud.

5. The Orbit of the Magellanic Clouds

5.1. Evidence for Recent Interactions

The discovery of the Magellanic Stream by Mathewson, Cleary & Murray (1974) provided the first dramatic evidence for a strong tidal interaction between the Magellanic Clouds ~ 1.5 Gyr ago (Gardiner & Noguchi 1996). A second encounter 0.2-0.3 Gyr ago is believed by Demers (U. Montreal) & Kunkel (OCIW) to have resulted in the formation of the Bridge between the LMC and SMC, and of the tidal tail behind the Small Cloud. Venn (Macalester College) found $[\text{Fe}/\text{H}] \sim -1.0$ for supergiants in the Bridge. This low metallicity suggests that gas in the Bridge was mainly drawn from the SMC. At the Symposium Putman (MSSSO) et al. reported the discovery of a narrow continuous gaseous tail, which leads the direction of motion of the Clouds, i.e., in the direction opposite to that of the Stream. Majewski (U. Virginia) et al. have searched for stars associated with the Magellanic Stream and reported that they have found a number of giant stars concentrated at distances expected for tidal debris from the Magellanic Clouds. Wakker (U. Wisconsin) et al. suspect that the high velocity cloud 287+22+240 may represent metal-poor material that originated in the Magellanic Stream.

5.2. The Orbit(s) of the Magellanic Clouds

Byrd et al. (1994) have modelled the interactions between the members of the Local Group from which they concluded that the Magellanic Clouds may have left the neighborhood of the Andromeda galaxy ~ 10 Gyr ago, and were subsequently captured by the Galaxy ~ 6 Gyr ago. Simulations by Sawa (Aichi U.) et al. also suggest that the LMC and SMC have formed a bound pair for ~ 15 Gyr. On the other hand detailed simulations by Li (U. Wyoming) & Thronson (NASA) show that the Small Cloud lost so much matter during its two most recent interactions with the Large Cloud that it cannot have survived many such interactions. They therefore concluded that the LMC and SMC must have captured each other fairly recently. Only greatly improved proper motions for the Clouds will place significant constraints on the evolution of their orbital history. Unfortunately the presently available data on their proper motions, which are listed in Table 1, show inconsistent motions.

6. Gravitational Lensing

Paczynski (1986) wrote that "Monitoring the brightness of a few million stars in the Magellanic Clouds over a time scale between 2 hr and 2 yr may lead to the discovery of "dark halo" objects in the mass range $10^{-6} - 10^{+2} M_{\odot}$ or it may put strong upper limits on the number of such objects." This prediction has

Table 1. Proper Motion of LMC in Milliarcseconds

$\mu_\alpha \cos \delta$	μ_δ	Method	Reference
$+1.20 \pm 0.28$	$+0.26 \pm 0.27$	Relative to galaxies	Jones et al. (1994)
$+1.94 \pm 0.29$	-0.14 ± 0.36	Hipparcos	Kroupa & Bastian (1997)
$+1.6 \pm 0.2$	$+3.0 \pm 0.2$	Relative to quasars	Anguita ¹ (1998)

¹These proceedings

been brilliantly confirmed by observations of the EROS, MACHO and OGLE consortia. Particularly exciting results, on the lensing event that took place in the SMC less than a month before the symposium, were reported by Alves (LLNL) et al. The lightcurve of this event showed that it was produced by a binary. Such data on microlensing of binaries can break the degeneracy between mass, location, and transverse velocity, that occurs in the standard gravitational microlensing model for single stars. In the case of the June 1998 event seen in the direction of the SMC, it was found that the observed proper motion of the lensing object is so small that there is only a 0.15% probability that it was produced by a foreground object in the Galactic halo. Previous observations of lensing events in the direction of the LMC had already excluded objects in the mass range $10^{-7} M_\odot$ to $1 M_\odot$ as significant contributors to the mass of the Galactic dark halo.

The EROS, MACHO and OGLE surveys have also produced a massive and homogeneous database on variable stars in the Clouds of Magellan. Investigations based on these new data on variable stars were reported by Welch (McMaster), Alves (LLNL) et al., Marquette (Inst. d'Ap.) and Bono (Trieste) et al.

7. Conclusions

- Geometrical distance determinations, based on observations of SN 1987A and of the detached eclipsing binary HV 2274, yield distance moduli of $(m - M)_\odot = 18.58 \pm 0.05$ and $(m - M)_\odot = 18.44 \pm 0.07$, respectively for the Large Magellanic Cloud. These values are both compatible with the canonical value $(m - M)_\odot = 18.5 \pm 0.1$, which corresponds to a distance of 50 kpc.
- The great burst of cluster formation that started in the LMC 3-5 Gyr ago is only weakly reflected in the rate at which field stars were formed. This strongly suggests that the rate of cluster formation is not a good diagnostic for the overall rate of star formation. The observation that the present rate of cluster formation, normalized to the rate of star formation

in the LMC, is more than two orders of magnitude greater than it is in the Local Group dwarf irregular IC 1613 supports this conclusion.

- Tidal interactions between the LMC and SMC that occurred ~ 0.2 Gyr and ~ 1.5 Gyr ago produced the Bridge and the Magellanic Stream, respectively. It is presently not clear if the LMC and SMC were closely bound between 3 Gyr and 13 Gyr ago. Improved proper motions are urgently required to constrain their orbital history.
- Observations of microlensing events strongly suggest that they are not produced by objects located in the Galactic halo. The enormous data base provided by the EROS, MACHO and OGLE consortia is proving to be a gold mine for the study of variable stars in the Clouds of Magellan.

References

- Baade, W. 1963, *Evolution of Stars and Galaxies* (Cambridge: Harvard Univ. Press), p. 231
- Butcher, H. 1977, *ApJ*, 216, 372
- Byrd, G., Valtonen, M., McCall, M., & Innanen, K. 1994, *AJ*, 107, 2055
- Caldwell, J.A.R., & Coulson, I.M. 1986, *MNRAS*, 218, 223
- Caldwell, J.A.R., & Maeder, D.L. 1992, in *Variable Stars and Galaxies = ASP Conference Series No. 30*, Ed. B. Warner (San Francisco: ASP), p. 173
- Cole, A.A. 1998, *ApJ*, 500, L137
- Da Costa, G.S. 1991, in *The Magellanic Clouds = IAU Symposium No. 148*, Eds. R. Haynes & D. Milne (Dordrecht: Kluwer), p. 183
- de Boer, K.S., Braun, J.M., Vallenari, A., & Mebold, U. 1997, *A&A*, 329, L49
- de Boer, K.S., Richter, P., Bomans, D.J., Heithausen, A., & Kuornneef, J. 1998, *A&A*, 338, L5
- Feast, M.W., & Catchpole, R.M. 1997, *MNRAS*, 286, L1
- Gardiner, L.T., & Noguchi, M. 1996, *MNRAS*, 278, 191
- Geha, M.C., et al. 1998, *AJ*, 115, 1045
- Haynes, R., & Milne, D. 1991, *The Magellanic Clouds = IAU Symposium No. 148* (Dordrecht: Kluwer)
- Hodge, P.W. 1998, Colloquium given at Victoria, B.C., April 21
- Hughes, J.P., et al. 1995, *ApJ*, 444, L81
- Jones, B.F., Klemola, A.R., & Lin, D.C.N. 1994, *AJ*, 107, 1333
- Kroupa, P., & Bastian, U. 1997, *New Astr.*, 2, 77
- Mathewson, D.S., Cleary, M.N., & Murray, J.D. 1974, in *The Formation and Dynamics of Galaxies = IAU Symposium No. 58*, Ed. J.R. Shakeshaft (Dordrecht: Reidel), p. 367
- Mighell, K.J., Sarajedini, A., & French, R.S. 1998, *AJ*, 116, 2395
- Oudmaijer, R.D., Groenewegen, M.A.T., & Schrijver, H. 1998, *MNRAS*, 294, L41
- Paczyński, B. 1986, *ApJ*, 304, 1
- Paczyński, B. 1998, *AcA*, 48, 405

- Reid, I.N. 1997, *AJ*, 114, 161
- Richter, P., et al. 1998, *A&A*, 338, L9
- Richtler, T., Spite, M., & Spite, F. 1991, in *The Magellanic Clouds = IAU Symposium No. 148*, Eds. R. Haynes & D. Milne (Dordrecht: Kluwer), p. 374
- Sarajedini, A. 1998, *AJ*, 116, 738
- Udalski, A., Szymański, M., Kubiak, M., Pietrzyński, G., Woźniak, P., & Żebruń, K. 1998, *AcA*, 48, 147
- van den Bergh, S. 1979, *ApJ*, 230, 95
- van den Bergh, S., & de Boer, K.S. 1984, *Structure and Evolution of the Magellanic Clouds = IAU Symposium No. 108*, (Dordrecht: Reidel)
- van den Bergh, S. 2000, *The Galaxies of the Local Group* (Cambridge: Cambridge Univ. Press), in preparation
- Westerlund, B.E. 1997, *The Magellanic Clouds* (Cambridge: Cambridge Univ. Press)
- Whitmore, B.C., & Schweizer, F. 1995, *AJ*, 109, 960